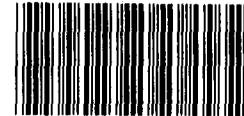
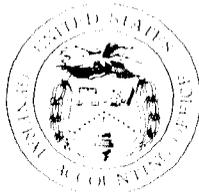


May 1990

MISSILE PROCUREMENT

Further Production of AMRAAM Should Not Be Approved Until Questions Are Resolved



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United States
General Accounting Office
Washington, D.C. 20548

National Security and
International Affairs Division

B-221734

May 4, 1990

The Honorable Denny Smith
House of Representatives

Dear Mr. Smith:

This report addresses the status of the Advanced Medium Range Air-to-Air Missile (AMRAAM) at the scheduled full-rate production milestone. As requested, we focused on the missile's demonstrated operational performance, the contractors' readiness to produce quality missiles at the required rates, and the latest program cost estimates.

The report concludes that significant questions about AMRAAM's performance, reliability, producibility, and affordability remain unresolved. It recommends that the Secretary of Defense not approve any additional AMRAAM production until (1) tests demonstrate that the missile can meet all of its critical performance requirements and that its reliability meets the established requirements, (2) both contractors demonstrate that they can consistently produce quality missiles at the rates required by their contracts, (3) the Air Force and the Navy complete their review of missile quantity requirements, and (4) the Department of Defense determines that the AMRAAM program is affordable within realistic future budget projections and consults with the Congress to ensure that the program complies with the adjusted statutory cost cap. The report also suggests that the Congress deny the \$1.34 billion requested for AMRAAM procurement in fiscal year 1991.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 5 days after its issue date. At that time we will send copies to the Secretaries of Defense, the Air Force, and the Navy; the Director, Office of Management and Budget; the House and Senate Committees on Armed Services and on Appropriations; and other interested parties.

This report was prepared under the direction of Nancy R. Kingsbury, Director, Air Force Issues, who may be reached on (202) 275-4268 if you or your staff have any questions concerning this report. Other major contributors to this report are listed in appendix I.

Sincerely yours,

Frank C. Conahan
Assistant Comptroller General

Executive Summary

Purpose

If a weapon system is authorized for production before tests demonstrate that it will be effective and reliable in combat, the risk that design changes will be required to the system increases. Such changes could disrupt production schedules and result in costly modifications.

Congressman Denny Smith requested that GAO review the status of the Advanced Medium Range Air-to-Air Missile (AMRAAM) program before the Defense Acquisition Board's review of the missile's readiness for full-rate production. Specifically, GAO assessed whether

- operationally realistic tests have demonstrated that AMRAAM will be effective and suitable in combat,
- AMRAAM's design is complete, stable, and producible by both contractors at the required rates, and
- the Air Force and the Navy can procure 24,000 missiles within the adjusted statutory cost cap.

Background

The Air Force and the Navy are jointly developing AMRAAM to replace the Sparrow missile. AMRAAM will be compatible with both services' latest fighter aircraft—the F-14, F-15, F-16, F/A-18, and Advanced Tactical Fighter—and is expected to have some key performance improvements over the Sparrow, such as the capability for a pilot to engage several targets simultaneously and then maneuver the aircraft to avoid counterattack.

Hughes Aircraft Company is the prime development contractor under a leader-follower acquisition strategy. Raytheon Company, the follower, continues to monitor and assist in the missile's development.

The Air Force and the Navy plan to procure 24,320 missiles between 1987 and 1998 at an estimated total acquisition cost of \$14.9 billion, including inflation. The Department of Defense has approved about \$2.4 billion in procurement funds for the first 3 years of low-rate initial production, during which 1,480 missiles will be produced.

In September 1989 GAO reported in Missile Procurement: AMRAAM Not Ready For Full-Rate Production (GAO/NSIAD-89-201, Sept. 7, 1989) that too many uncertainties existed in the AMRAAM program to warrant the approval of full-rate production. In December 1989 the Department of Defense authorized funds for long-lead items for the fourth production year but did not authorize production of the missile. In May 1990 the Defense Acquisition Board plans to make a full-rate production review

and a recommendation to the Secretary of Defense on whether the program should proceed into full-rate production, return to full-scale development, or be terminated. The President's fiscal year 1991 budget requests \$1.34 billion for the full-rate production of 1,800 missiles in the fifth production year.

Results in Brief

At the completion of GAO's review in March 1990, significant questions about AMRAAM's performance, reliability, producibility, and affordability remained unresolved. A few critical performance requirements have not yet been demonstrated in testing. AMRAAM's reliability remains unacceptable despite many design changes to improve the missile's reliability. The contractors were at least 6 months behind in missile deliveries, and some of the problems that delayed production had not been resolved. Total estimated procurement cost had increased substantially, exceeding the adjusted statutory cost cap. In view of the continuing problems, GAO believes that the Secretary of Defense should not approve any additional production until the significant questions about the missile are resolved. GAO also believes that the Congress should deny funds requested for AMRAAM procurement in fiscal year 1991.

Principal Findings

A Few Critical Performance Requirements Have Not Yet Been Demonstrated

Tests have demonstrated many of AMRAAM's performance requirements, but a few critical requirements have not yet been proven. For example, the Air Force has not shown that AMRAAM provides pilots with the capability to engage four targets simultaneously or that AMRAAM can be effectively used with the Sparrow missile. Additional tests with initial production missiles were to address these and other issues, but the tests had not been completed as of March 1990.

Operational Reliability Is Unacceptable

In September 1989 GAO reported that AMRAAM's reliability was unacceptable because it could not withstand the vibration and other environmental conditions that it is exposed to when carried on the F-15 aircraft. AMRAAM's reliability remains unacceptable despite many changes to improve the missile's reliability. In flight tests conducted by the Air Force's independent test organization from December 1989 through March 1990, 10 missile failures occurred within 895 flight hours. This

computes to an average time of only about 90 hours between maintenance, which is far below the interim requirement of 200 hours set for the full-rate production decision and the final requirement of 450 hours. In February 1990 the Air Force stopped accepting missiles until the reasons for the failures are understood and the problems resolved.

Design Changes and Manufacturing Problems Continue

Neither contractor has demonstrated the ability to produce quality missiles at a consistent rate, much less a steadily increasing rate. Both contractors were at least 6 months behind their latest approved production schedules. Design changes and manufacturing problems continued to delay production. Both contractors were reviewing design specifications and production process controls at their plants and subcontractor plants to improve the quality and reliability of future missiles.

Estimated Costs Increase Significantly

The Air Force's most recent estimate in 1984 dollars shows that the cost to procure 24,320 AMRAAMS has increased to \$9.4 billion, which is 24 percent above the adjusted statutory cost cap of \$7.6 billion. With inflation, the total procurement cost is estimated to be \$13.5 billion, 31 percent more than the previous estimate of \$10.3 billion. The increase occurred primarily because of changes in certain assumptions, such as the amount of savings to be realized from contractor competition and the rate at which the contractors will become more efficient. Unless the administration and the Congress provide between \$0.9 billion and \$1.7 billion annually for the next 8 years, procurement costs will increase even further due to, among other things, higher overhead charges per missile and less-than-optimal component procurement quantities.

The Air Force and the Navy are reviewing their AMRAAM quantity requirements, and the Air Force is preparing a plan that assumes that a total of only 15,500 missiles will be procured. A reduction in the number of missiles to be procured would decrease the total procurement cost but increase the cost of each missile.

Recommendation

GAO recommends that the Secretary of Defense not approve any additional AMRAAM production until (1) tests demonstrate that the missile can meet all of its critical performance requirements and that its reliability meets the established requirements, (2) both contractors demonstrate that they can consistently produce quality missiles at the rates required by their contracts, (3) the Air Force and the Navy complete their review of missile quantity requirements, and (4) the Department of

Defense determines that the AMRAAM program is affordable within realistic future budget projections and consults with the Congress to ensure that the program complies with the adjusted statutory cost cap.

Matter for Congressional Consideration

GAO believes the Congress should deny the \$1.34 billion requested for AMRAAM procurement in fiscal year 1991 because the missile's performance, reliability, producibility, and affordability remain questionable. Moreover, missile deliveries from the first production year are at least 6 months behind schedule, and additional delays appear likely. Because funds have already been appropriated for three additional production years, it is highly unlikely that additional procurement funds will be necessary before fiscal year 1992. Should the contractors resolve their manufacturing problems and begin to produce quality missiles consistently, ample opportunity would be available to rephase delivery schedules to preclude any gaps in production. Denying the funds would reduce financial risks while the Under Secretary of Defense for Acquisition determines if reliability problems can be resolved and if the contractors can recover delivery schedules.

Agency Comments

As requested, GAO did not obtain official agency comments on this report. However, GAO discussed a draft of this report with officials responsible for managing the program at the Office of the Secretary of Defense, the Air Force, and the Navy and incorporated their comments where appropriate.

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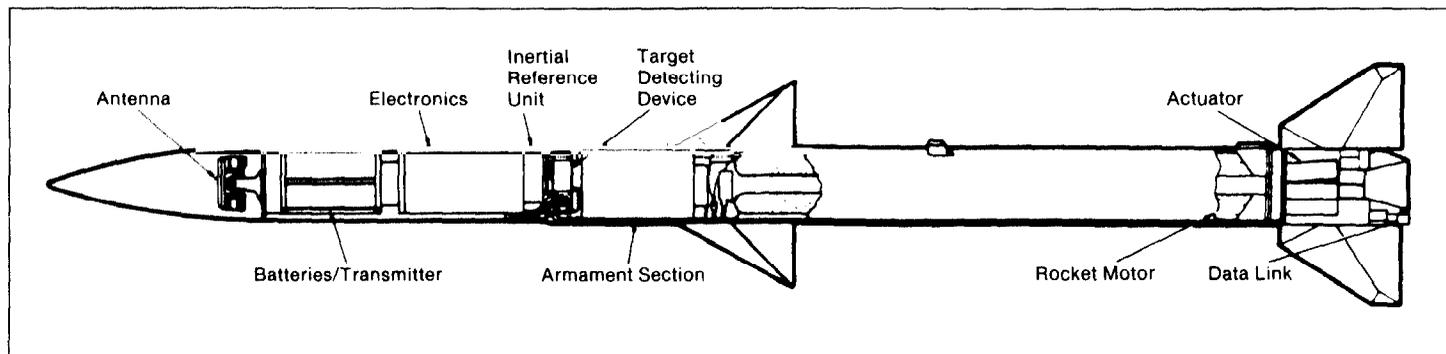
Abbreviations

AMRAAM Advanced Medium Range Air-to-Air Missile
GAO General Accounting Office

Introduction

The Air Force and the Navy are jointly developing the Advanced Medium Range Air-to-Air Missile (AMRAAM) to meet their air-to-air missile requirements into the next century.¹ The primary goal of the AMRAAM program is to produce an all-weather, medium range missile that will enable a pilot to simultaneously engage multiple aircraft in combat. The missile is to destroy targets both within and beyond the pilot's visual range and is to be compatible with both services' latest fighter aircraft: the F-14, F-15, F-16, F/A-18, and Advanced Tactical Fighter. The AMRAAM, shown in figure 1.1, is about 12 feet long and weighs about 345 pounds.

Figure 1.1: The AMRAAM



AMRAAM is to replace the Sparrow missile, several versions of which have been in production for the Air Force, the Navy, and numerous foreign countries since the late 1950s. AMRAAM is intended to improve aircraft combat effectiveness and to be more reliable and maintainable than the Sparrow. It has some improved performance features over the Sparrow, including higher speed, greater range, increased maneuverability, and better resistance to electronic countermeasures. In addition, AMRAAM has an active terminal seeker that enables the missile's on-board radar to acquire and guide to a target autonomously, unlike the Sparrow, which has a semi-active seeker that requires the launch aircraft to illuminate the target with its radar until missile impact. AMRAAM's seeker and the launch aircraft's radar are to enable the pilot to track multiple targets, launch multiple missiles, and maneuver the aircraft to avoid counterattack. AMRAAM is designed to guide close to the target and detonate its warhead within lethal range of the target.

¹The Air Force is the lead procuring service. The Joint System Program Office located at Eglin Air Force Base, Florida, is the primary office responsible for managing development and production.

Most of the testing has been done by the Air Force, but the Navy plans to begin its operational testing in the near future. Because the missile's initial operational capability is planned to be achieved on the Air Force's F-15, most of its developmental and initial operational testing has been conducted using that aircraft.

Hughes Aircraft Company is the prime development contractor under a leader-follower acquisition strategy. During full-scale development, Raytheon Company, the follower, monitored the Hughes design effort and produced 15 missiles to qualify as a second producer. During production, Raytheon continues to monitor and assist with design changes to the missile.

Through fiscal year 1990, the Congress had appropriated about \$3.2 billion for the first 4 years of AMRAAM production. These funds are expected to procure a total of 2,380 missiles. Of the \$3.2 billion, \$795.9 million was appropriated to procure 900 missiles in fiscal year 1990. However, the Secretary of Defense decided not to approve production of these missiles until after the Under Secretary of Defense for Acquisition makes a recommendation on AMRAAM's readiness for full-rate production. In December 1989, the Under Secretary decided to release only limited funds to procure long-lead items and not approve production of those missiles until after AMRAAM's readiness for full-rate production is determined.

The President's fiscal year 1991 budget requests \$1.34 billion for the full-rate production of 1,800 missiles in the fifth production year. The Air Force and the Navy plan to buy a total of 3,000 missiles each year from 1992 through 1997 and 2,140 missiles in 1998, which is expected to be the final production year. Both services' budget request for fiscal year 1992 is expected to total \$1.67 billion.

The Air Force and the Navy expect to spend a total of about \$1.34 billion for AMRAAM research and development. Through fiscal year 1989, about \$1.1 billion had been spent. According to the December 1989 Department of Defense Selected Acquisition Report, the total cost for 24,320 missiles—procured over a 12-year period—is projected to be \$13.54 billion, with inflation. Without inflation, this amounts to \$9.4 billion (in 1984 dollars).

The Defense Acquisition Process

Major defense system acquisitions typically proceed through several phases, with each phase preceded by a senior management review at the military service and/or the Department of Defense level. These reviews are referred to as milestone decisions. The milestone "0" decision considers whether a system should proceed into the concept exploration phase, during which alternative system concepts are identified and evaluated. The milestone "I" decision considers whether a system should proceed into the demonstration and validation phase, during which test articles are fabricated and tested to see if they can perform generally as expected. The milestone "II" decision considers whether one or more systems should proceed into full-scale development. During this phase, several test articles, or prototypes, are made and undergo numerous tests to ensure that the design meets system requirements. The milestone "III" decision considers whether the system should be produced and fielded. Frequently, the Department of Defense and the military services divide the production decision into two increments: milestone "IIIA" and "IIIB." Milestone IIIA is for low-rate initial production and is to provide articles for additional testing and to allow contractors to prove needed manufacturing techniques and controls. Milestone IIIB is to authorize full-rate production.

Within this general framework, the Department of Defense tailors the acquisition phases for a particular program to that program's needs and risks. As a result, phases can be combined or can run concurrently, that is, production can start before development is complete.

AMRAAM's Acquisition History

The AMRAAM program began in October 1975 when an Air Force and Navy tactical working group defined requirements for air-to-air weapons for 1985 and beyond. The Congress approved the missile's development in July 1976. During the concept exploration phase, five contractors—General Dynamics, Hughes, Northrop, Ford Aeronitronics, and Raytheon—explored critical technologies and compared alternate system configurations to meet operational requirements. In November 1978 the Secretary of Defense approved the program's transition to the demonstration and validation phase. In February 1979 two contractors—Hughes and Raytheon—were selected for a 33-month competitive effort to determine the primary design contractor for full-scale development. The Air Force awarded Hughes a 54-month full-scale development contract in December 1981.

AMRAAM's schedule slipped and costs increased significantly during the full-scale development phase. In January 1985 the Secretary of Defense

expressed concern over the schedule delays and rising costs and ordered a complete program review to determine if and how costs could be reduced. As a result of this review, the Air Force began a program to reduce production costs by redesigning many of the missile's components to make them more producible. The Air Force also extended the full-scale development phase from 54 to 79 months and postponed the initial operational capability date from 1986 to 1989. At the completion of our review in March 1990, the operational capability had not been achieved.

The National Defense Authorization Act for fiscal year 1986 required the Secretary of Defense to certify to the House and Senate Committees on Armed Services by March 1, 1986, that AMRAAM would meet certain cost and performance requirements or the program would be terminated. On February 28, 1986, the Secretary certified² to each requirement, including that the design was complete and that the Air Force could buy a minimum of 17,000 missiles for \$5.2 billion (in 1984 dollars).³ Later, the National Defense Authorization Act for fiscal year 1987 established a cost cap of \$7 billion (in 1984 dollars) for the procurement of 24,000 missiles. These figures were derived by adding Navy procurement quantities and estimated costs to the amounts certified in 1986.

In June 1987 the Secretary of Defense approved funding for the first year of AMRAAM low-rate initial production, and the contractors are in the process of producing 180 missiles that contain an interim software configuration known as tape 3A.⁴ The Air Force is using some of the missiles for additional testing while others are being placed in inventory to achieve AMRAAM's initial operational capability on the F-15 aircraft.

The Defense Acquisition Board reviewed the program's status and test results in May 1988. On the basis of the Board's recommendation, the Secretary approved the production of 400 full-capability missiles, known as tape 4, for the second production year. The tape 4 missiles should perform better than the tape 3A missiles against some electronic countermeasures that the enemy is expected to use to confuse AMRAAM

²In March 1986 we testified before the Subcommittee on Procurement and Military Nuclear Systems, House Committee on Armed Services, that, although uncertainties about AMRAAM's cost, schedule, and performance continue, the Secretary's certification had met the legal requirements of the legislation.

³This estimate was based on a total procurement of 24,000 missiles.

⁴AMRAAM software was developed in five incremental stages, referred to as tapes 1, 2, 3, 3A, and 4.

and degrade its performance. According to the AMRAAM program manager, the tape 4 missiles also provide additional multiple target capabilities over the tape 3A missiles.

In May 1988 the Board also reviewed the Air Force's request to procure long-lead items for the first year of AMRAAM full-rate production but chose to defer its decision until more tape 4 developmental and operational test data were available. In September 1988 the Board's Conventional Systems Committee decided that AMRAAM was not ready for full-rate production and recommended that the quantity of missiles for the third production year be reduced from 1,270 to 900. The Committee also recommended that the Air Force be permitted to proceed with the procurement of the long-lead items but decided to review the program again before authorizing fabrication of the 900 missiles. In June 1989 the Committee decided to postpone a final decision on fabrication of the 900 missiles until more reliability test data could be obtained.

In December 1989 the Board, citing improved reliability, approved the fabrication of 900 missiles for the third production year and authorized the Air Force to commit up to \$84.5 million of fiscal year 1990 funds for long-lead items and producibility enhancements for the fourth production year. However, the Board did not authorize that production year as a part of low-rate initial production. The Board decided to review the program again in May 1990, before making a recommendation to the Secretary of Defense on whether the program should proceed into full-rate production, return to full-scale development, or be terminated. The Under Secretary of Defense for Acquisition has stated that continued low-rate production is not an option.

The National Defense Authorization Act for fiscal years 1990 and 1991 includes a provision that restricts the Air Force from proceeding to full-rate production—defined as producing more than 900 missiles per year—until the Director of Operational Test and Evaluation certifies that all required testing has been completed, the results demonstrate the missile has met its stated performance goals, and a stable design, including software, has been established.

Recent GAO Reports

Shortly after the June 1987 program review, which recommended approval of AMRAAM's initial production, we reported in Missile Development: Development Status of the Advanced Medium Range Air-to-Air Missile (GAO/NSIAD-87-168, Aug. 14, 1987) that the missile's unstable design and small number of completed tests increased production risks.

The decision to approve the first year of low-rate initial production was made 13 months before the then-scheduled completion of full-scale development. Later development delays increased the overlap between development and production to 19 months.

Shortly after the May 1988 program review, which resulted in approval of AMRAAM's second year of production, we reported in Missile Development: AMRAAM's Combat Effectiveness at Production Not Fully Tested (GAO/NSIAD-88-186, July 7, 1988) that the Air Force had not completed tests needed to make a full and accurate assessment of the missile's performance and that completed tests had identified performance and reliability problems that had not been resolved. Therefore, we concluded that the combat effectiveness and reliability of missiles to be produced for the operational inventory were uncertain.

In September 1989 we reported in Missile Procurement: AMRAAM Not Ready For Full-Rate Production (GAO/NSIAD-89-201, Sept. 7, 1989) that AMRAAM was not ready to proceed into full-rate production. The report cited performance requirements that had not been demonstrated, reliability that was unacceptable, and continued design changes that were disrupting production deliveries from both contractors. We recommended that the Secretary of Defense not authorize AMRAAM for full-rate production until realistic tests demonstrate that the missile will be effective and reliable, the design stabilizes, and production readiness reviews show that the contractors can produce quality missiles at the required rates.

Objectives, Scope, and Methodology

Congressman Denny Smith asked us to report on the status of the AMRAAM program before the Defense Acquisition Board considers the missile's readiness for full-rate production. Specifically, we assessed whether

- operationally realistic tests have demonstrated that AMRAAM will be effective and suitable in combat,
- the missile's design is complete, stable, and producible by both contractors at the required rates, and
- the services can procure 24,000 missiles within the adjusted statutory cost cap.

We obtained information from records and officials primarily within the AMRAAM Joint System Program Office. We also discussed AMRAAM's status and testing issues with officials in the following organizations.

Office of the Secretary of Defense

- Office of the Under Secretary of Defense for Acquisition
- Director, Operational Test and Evaluation
- Director, Live Fire Test

Department of the Air Force

- Headquarters
- Headquarters, Tactical Air Command
- Systems Command, Munitions Systems Division
- Operational Test and Evaluation Center

Contractors

- Hughes Aircraft Company
- Raytheon Company

To determine whether tests have demonstrated AMRAAM's operational effectiveness and suitability, we reviewed test reports, compared planned and actual test schedules, and correlated the individual test results with the critical performance issues that were to be addressed. We examined the results of reliability flight tests, various ground tests, and air-to-air missile firings. We witnessed selected guided flight tests and discussed test results with Air Force, Navy, and Office of the Secretary of Defense officials responsible for conducting and monitoring the tests.

To assess design stability, we reviewed pertinent regulations and the results of key activities intended to determine design progress. These activities included design reviews, component qualification tests, engineering change proposals, deviations and waivers, functional and physical configuration audits, and the plan for resolving open items from these reviews. We also reviewed the results of previous production readiness reviews and the extent to which contractors were meeting scheduled deliveries under the contracts for the first and second years of production. During our visits to both Hughes and Raytheon, we discussed design changes and manufacturing problems that delayed production deliveries and must be overcome to ensure that both contractors can deliver reliable missiles at the required rates.

To evaluate estimated costs, we reviewed the latest approved cost estimate contained in the December 1989 Selected Acquisition Report. We

also reviewed key events that have changed or may change the assumptions supporting the cost estimate and discussed the status of cost reduction efforts with Air Force and contractor officials.

We conducted our review from August 1989 through March 1990 in accordance with generally accepted government auditing standards. As requested, we did not obtain official agency comments on this report. However, we discussed a draft of this report with officials responsible for managing the program at the Office of the Secretary of Defense, the Air Force, and the Navy and incorporated their comments where appropriate.

AMRAAM's Reliability Is Unacceptable

The Department of Defense has approved the first 3 years of low-rate initial production in which 1,480 missiles will be produced at a cost of about \$2.4 billion, without demonstrating that AMRAAM is suitable for deployment. All but a few critical performance requirements have been demonstrated but AMRAAM's reliability is unacceptable. As of March 1990, the Air Force had stopped accepting missiles from both contractors because of continued reliability problems.

Importance of Testing Before Production

In May 1990 the Defense Acquisition Board plans to make a recommendation to the Secretary of Defense on AMRAAM's readiness for full-rate production. Department of Defense Directive 5000.3, "Test and Evaluation," requires that test objectives be accomplished before committing significant resources to a weapon system or advancing a system from one acquisition phase to another. Several statutes governing major system acquisitions stipulate that a system⁵ may not proceed beyond low-rate initial production until (1) independent tests prove that the system will be effective and reliable when used under realistic, combat-like conditions, (2) the Director, Operational Test and Evaluation, assesses the system's operational effectiveness and suitability and reports the results to the Secretary of Defense and the House and Senate Committees on Armed Services and on Appropriations, and (3) realistic survivability or lethality testing of the system is completed and the Secretary of Defense submits a report on the testing to the defense committees of the Congress. These reports are expected to be finalized and presented to the Defense Acquisition Board for its scheduled review of AMRAAM in May 1990.

A Few Critical Capabilities Have Not Been Demonstrated

Since our September 1989 report, tests have demonstrated additional AMRAAM performance capabilities. For example, tests have shown that improved missile software was effective against a specific electronic countermeasure that caused one missile to fail during a previous test. Also, according to a draft report being prepared by the Department of Defense's Office of Live Fire Test, tests have shown that AMRAAM's warhead is lethal. Other tests have shown that AMRAAM can be successfully launched during a variety of aircraft maneuvers. Nevertheless, tests to demonstrate the few remaining critical performance requirements had not been completed, as discussed below.

⁵Somewhat different rules apply to those programs, such as space systems and ships, that involve procurement of a few items over an extended period.

Multiple Targets

AMRAAM is to provide the pilot with the capability to engage multiple resolved targets⁶ simultaneously. The Air Force's Tactical Air Command, which represents operational units that would use the missile in combat, considers this to be a critical requirement. However, the Air Force has not yet demonstrated that the missile can fully meet this requirement.

An August 2, 1989, test failed to show that one aircraft could simultaneously engage four resolved targets in an electronic countermeasure environment with four AMRAAMS. According to the test report, three of the four missiles missed their targets because of software deficiencies in the F-15 aircraft's fire control system, and one missile missed its target because of a missile software deficiency.

After the test, the Air Force modified the aircraft and missile software and structured a series of tests to demonstrate that the problems were resolved. The series involves four tests of increasing complexity, including a repeat of the August 1989 test.

The first three tests were successful. In November 1989, an AMRAAM with upgraded software successfully hit a target in an electronic environment similar to the one used in the earlier four-missile test. In February 1990 an F-15 with upgraded software successfully engaged one of two resolved targets—only one missile was launched—in an environment that included most of the electronic countermeasures used in the August 1989 test. In March 1990 an F-15 launched two missiles and successfully engaged two resolved targets in the same electronic environment used in the August 1989 test. One missile scored a direct hit, and the second passed within lethal radius of the target.

At the completion of our review, the repeat of the August 1989 test was scheduled for early May 1990. The Under Secretary of Defense for Acquisition has determined that the test will be considered successful if at least two of four missiles successfully engage their targets.

Tests With Live Warheads

In addition to the four developmental flight tests with warheads already conducted—two of which were successful—the Air Force's independent test center requires that an AMRAAM with a live warhead produced by each contractor be successfully flight tested before the full-rate production decision. The first two missiles received, one from each contractor,

⁶Targets are resolved when they appear as discrete symbols on an aircraft's radar display.

failed to pass ground tests at the test site and were returned to the contractors. A second Hughes missile, launched in February 1990, successfully destroyed its target. A second Raytheon missile is scheduled to be launched in late April 1990.

Weapon System Compatibility

In March 1989 the Director, Operational Test and Evaluation, concluded that AMRAAM and Sparrow compatibility must be adequately addressed for an adequate initial operational test and evaluation to support the full-rate production decision. However, the Air Force does not expect to conduct the planned flight test to demonstrate AMRAAM and Sparrow compatibility before the May 1990 decision.

The Air Force's independent test center attempted the test in May 1989 but aborted it because changes made to the aircraft radar software precluded the launch of either missile. The aircraft radar software has been modified, but, because of higher priorities, the Air Force has postponed the compatibility test until after the planned full-rate production decision. The Director, Operational Test and Evaluation, had not reached a conclusion on the extent to which the failure to conduct the compatibility test would limit the adequacy of operational test data to support its assessment of AMRAAM's operational effectiveness and suitability. That assessment must be accomplished before the full-rate production decision.

AMRAAM's Reliability Still Unacceptable

Reliability is an important aspect of AMRAAM's or any other missile's suitability for deployment. Although many combat missions would not expose the missile to long periods of stressful flight on the aircraft before launch, other combat and peacetime missions would.

At the completion of our review, the Air Force had not demonstrated that AMRAAM could meet its reliability requirement. Through March 1990, independent tests had demonstrated an average time between maintenance of only about 90 hours, which is far short of the 200-hour criterion established for the full-rate production decision.⁷ Also, reliability failures had been experienced on at least three of the four missiles used in the Navy's recent tests to integrate AMRAAM on the F/A-18. As a result, the Air Force stopped accepting production missiles from both contractors in February 1990.

⁷The 200-hour criterion is an interim requirement toward the 450-hour average time between maintenance specified in the Joint Service Operational Requirement.

In May 1989 the Air Force's independent test center stopped its involvement in AMRAAM reliability testing because the early results were unacceptable. That was the latest of several unsuccessful attempts by the test center to demonstrate AMRAAM's reliability. As we reported in September 1989, the Air Force attributed AMRAAM's reliability problems primarily to the more-severe-than-expected environment encountered when carried on the F-15 aircraft. Although AMRAAM completed environmental qualification tests in September 1988, the Air Force has since learned that the technical parameters used to design and test the missile were not representative of the actual environment in which AMRAAM will have to operate. After the missile's production began, the Air Force discovered that the F-15 fuselage environment is much more severe than the levels and durations included in the missile's design specifications.

From May through November 1989, the Air Force and the contractors conducted extensive analyses and ground and flight tests to identify design and other changes to improve the missile's reliability. Each contractor incorporated the changes and delivered six production missiles to the independent test center in late 1989.

On December 11, 1989, the Under Secretary of Defense for Acquisition authorized the Air Force to proceed with AMRAAM's third production year "based on the progress made in missile reliability over the past six months." The Under Secretary also notified the Air Force that AMRAAM must average 200 flight hours between maintenance during a 1,000-hour test program before the full-rate production decision.

The independent test center resumed reliability testing in December 1989, but initial results were not encouraging. Test missiles began to fail almost immediately, and at the completion of our review, 10 missile failures had occurred in the first 895 test hours.

In addition, reliability problems were experienced on at least three of the four missiles that the Navy launched during F/A-18 integration tests made between October 1989 and February 1990. The primary purpose of these tests is to demonstrate that AMRAAM will perform effectively on the F/A-18, and the secondary purpose is to guide the missiles to their targets. In all four tests, the missiles separated properly from the aircraft but did not guide to the targets. The Air Force and the Navy still do not know why the fourth missile failed.

In other instances, Air Force test missiles failed ground tests at the test site before they were used in flight tests. For example, the first missiles

delivered for use in live warhead tests failed the ground tests and were returned to the contractors. These failures occurred despite each contractor's additional environmental stress screening of all missiles before shipment to the test sites or the operational inventory. This screening process for both missile sections and complete missiles consists of a short duration test that is supposed to be equivalent to about 40 to 60 hours of F-15 flight time.

As a result of reliability failures, the Air Force notified both contractors in February 1990 that the government will not accept additional missiles until the causes for the failures are better understood and the problems are corrected. The Air Force also has established a special team to study the problems, but the team had not issued its report at the completion of our review.

Continuing Design Changes and Production Problems

Neither contractor has demonstrated the ability to produce quality missiles at consistent rates, much less at steadily increasing rates. At the completion of our review, both Hughes and Raytheon were at least 6 months behind their latest approved delivery schedules. Tests and analyses were continuing to identify design changes to improve AMRAAM's reliability and resolve production problems that had delayed and disrupted missile deliveries throughout the first production year. Early results from the most recent reliability tests indicated that more design changes will be needed. Also, the Air Force has not completed qualification tests to determine if all of the missile's components can withstand the higher-than-anticipated F-15 vibration levels.

Importance of Design Stability

Until the design stabilizes, the effectiveness, suitability, and producibility of a weapon system cannot be predicted with certainty. According to Department of Defense Manual 4245.7-M, "Transition from Development to Production," a stable design provides confidence that a system has overcome development problems and that it will meet defined technical and operational performance requirements. Beginning full-rate production before the design stabilizes increases the risk that production schedules will be disrupted, weapons will not perform satisfactorily, different missile configurations will enter inventory and have to be maintained, and costly retrofit programs will be required.

Contractors Have Not Met Production Schedules

As of March 1990 both Hughes and Raytheon were at least 6 months behind their latest approved production delivery schedules, and neither had shown the ability to deliver missiles consistently. Figures 3.1 and 3.2 show the contractors' planned and actual deliveries through January 1990 under the first production year contracts.

Figure 3.1: Hughes' Scheduled and Actual Missile Deliveries Per Month

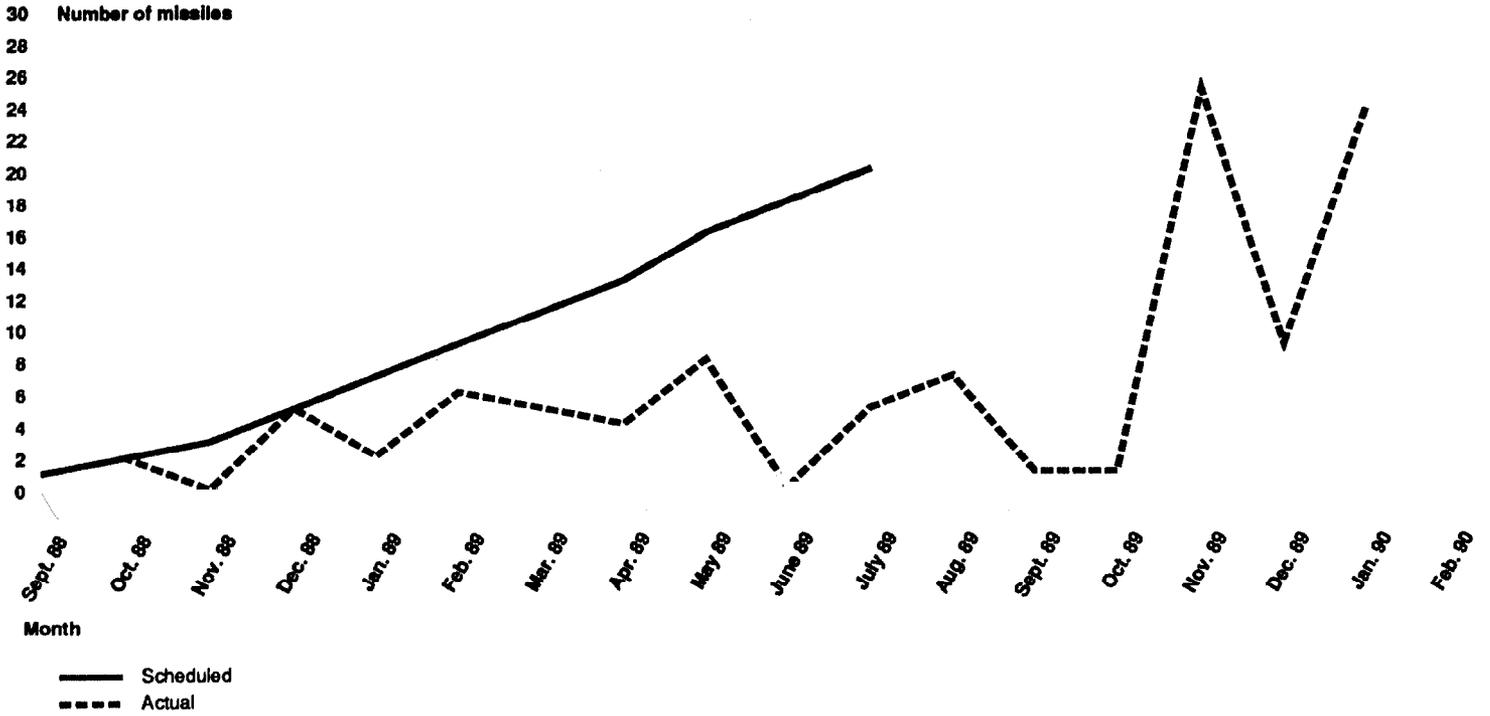
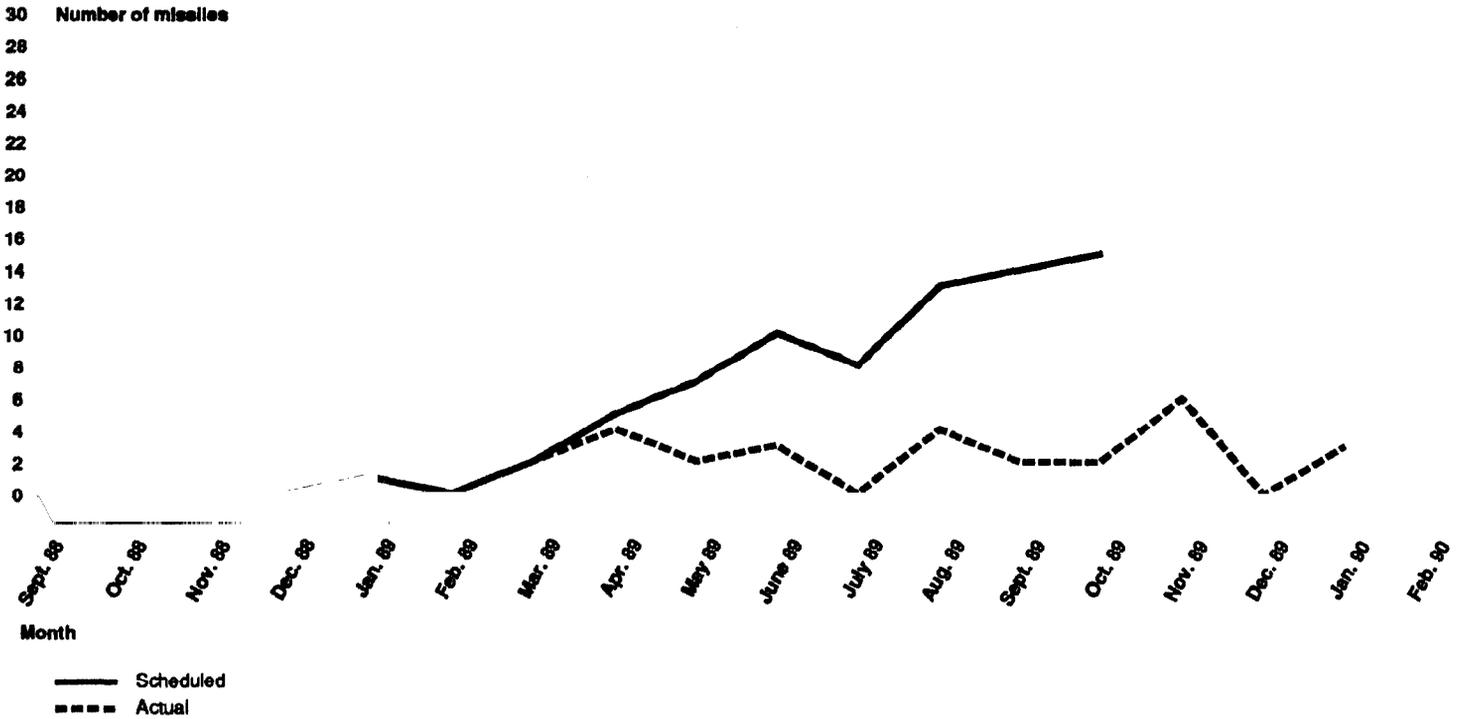


Figure 3.2: Raytheon's Scheduled and Actual Missile Deliveries Per Month



Hughes did not complete delivery of first production year missiles until January 1990, 6 months beyond schedule. At the completion of our review, Raytheon also was at least 6 months beyond its scheduled delivery date and was expected to complete its deliveries of first production year missiles in May 1990. Both contractors were to have started delivering second production year missiles in August 1989, but, as of March 1990, none of these missiles had been delivered. Moreover, in early February 1990, the government stopped accepting missiles until the causes for reliability problems are better understood and resolved. At that time, the contractors had delivered a total of only 134 of the 380 missiles required by their contracts to be delivered by that date. At the completion of our review, the Air Force was attempting to identify realistic, achievable missile delivery schedules for the second through fourth production years.

Reasons for Production Delays

Design and manufacturing process changes and quality and subcontractor problems have disrupted production schedules and delayed missile deliveries despite both contractors' additional production shifts and extended workweeks.

Production delays were caused in part by numerous design, quality, and manufacturing process changes needed to improve AMRAAM's reliability. For example, flexible electrical connecting strips broke frequently, and ceramic circuit cards came loose when exposed to the F-15 vibration levels. These problems were corrected by using an alternate design for the flexible connectors and an improved bonding at the corners of the ceramic cards.

Another design problem, also attributed to the F-15 vibration levels, was that the missile wing alignment pin and hole were wearing excessively, thus exceeding the maximum movement permitted for effective performance. The Air Force has accepted a "saddle" design, which bolts into the missile to better hold its wings straight, to correct this problem for the second and third production year missiles. Ground vibration tests indicate, however, that additional changes will be required for the missile wing to achieve a reliability value of 450 hours between maintenance, which is required 2 years after the missile achieves its initial operational capability.

Subcontractor problems also have contributed to production delays. For example, the safe and arm mechanism, a safety device that prevents the warhead from detonating prematurely, failed tests designed to ensure that production units are acceptable. Because the tests revealed a number of problems, the devices had to be reworked. Additionally, the only qualified supplier of the devices ceased operations and filed for bankruptcy before the units were reworked. After a delay of several months, Hughes' devices have been reworked and incorporated into its first production year missiles. Raytheon anticipates having all of its devices reworked and ready for its first production year missiles by early 1990. Both Hughes and Raytheon are qualifying alternate production sources.

Continuing Design Changes and Manufacturing Problems May Impact Future Deliveries

Further design changes may be needed to overcome continuing reliability problems. These changes could adversely affect future missile deliveries. Also, other production problems that have delayed first production year deliveries—including shortages of certain missile components—have not been resolved.

Independent Tests Identify Additional Problems

Three days after the latest reliability tests resumed, a welded joint in the missile's guidance section cracked, resulting in the missile's failure after only 2 flight hours. For safety reasons, flight testing was stopped until the problem could be corrected. An investigation concluded that this failure resulted from a workmanship problem at a subcontractor that supplies both contractors. The investigation also found that the specifications and inspection procedures included in the technical data package were not adequate to ensure acceptable welds. In addition to changing the data package, all missiles, including those accepted for the operational inventory, had to be reworked at the manufacturers.

When testing resumed in January 1990, a wing fell off a missile after 14 flight hours. The cause of this problem was also traced to poor workmanship. Hughes determined that during a minor modification to improve the wing's reliability, a worker did not properly apply a coating designed to keep the threaded device from loosening. Also, Hughes has since increased the torque value in the specifications to ensure that the device is adequately tightened.

In early February 1990, five additional missile failures occurred. Although additional analyses were continuing as we completed our review, these five failures have been categorized primarily as a combination of component reliability failures and manufacturing process problems and errors. However, because of the seven total failures discovered at that point, each in different parts of the missile, the Air Force notified both contractors on February 8, 1990, that the government would not accept additional production deliveries until the problems causing the failures were better understood and corrected. In March 1990, 3 additional missile failures occurred, for a total of 10 since this phase of testing started in December 1989. As we completed our review, the Air Force was still analyzing the causes of these latest missile failures.

Some Missile Components Not Tested to Higher F-15 Vibration Levels

The Air Force has not completed qualification tests to determine if all of the missile's components can withstand the higher F-15 vibration levels. For example, ground testing of AMRAAM's rocket motor and warhead are expected to be completed by April 1990. For safety reasons, the Air Force's independent test center uses test missiles that contain inert rocket motors and warheads, not the actual warhead and rocket motor, to test AMRAAM's reliability.

Additionally, the Air Force has funded 24 projects to redesign AMRAAM components to make them easier to produce and thereby less costly. However, only 6 of these projects have been successfully tested on a laboratory basis to the higher F-15 vibration levels; the remaining 18 projects are still in development.

Continuing Manufacturing and Subcontractor Problems

Both contractors are continuing to experience problems producing quality parts and subassemblies at the planned rates. In many instances the individual parts pass required inspections and tests, but higher level assemblies, which include the parts, fail. The contractors are attempting to develop additional tests and inspections to find these problems earlier and are reviewing the specifications to see if additional inspections are needed to overcome the problems.

In addition, component and material shortages from other suppliers also may affect future delivery schedules. For example, during our January 1990 visits to both contractors' manufacturing facilities, we noted that detailed schedules showed continuing shortages of certain missile components. These shortages were the result of subcontractors having difficulties supplying adequate quantities of several missile components such as the warhead, the rocket motor, the radio frequency head, the inertial reference unit, and the safe and arm mechanism.

At the completion of our review, both contractors were reviewing design specifications and process controls in their plants and at their subcontractors to resolve problems and ensure the quality and reliability of future missile deliveries.

Production Readiness Assessments Delayed

At the time of our September 1989 report, Air Force assessments to determine the contractors' readiness for full-rate production had been delayed from March to November 1989. This additional time was needed for the contractors to overcome problems that were delaying production.

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Since then, the Air Force has delayed the date of the contractors' readiness reviews to April 1990.

Estimated Costs Increase Significantly

AMRAAM's estimated procurement cost in 1984 dollars has increased to \$9.4 billion, or 24 percent above the \$7.6 billion adjusted statutory cost cap for the procurement of 24,000 missiles. With inflation, AMRAAM's total procurement cost is now estimated at \$13.5 billion—a 31-percent increase over the December 1988 estimate of \$10.3 billion. The cost increase is due primarily to changes in key assumptions, such as the amount of savings from contractor competition and the rate that costs decrease which normally results as the contractors learn to produce missiles more efficiently. In addition, the cost estimate assumes that between \$0.9 billion and \$1.7 billion will be appropriated each year for the next 8 years. The total AMRAAM procurement cost will increase even further if the administration and/or the Congress fail to provide those funding levels.

Long-Standing Congressional Concern About AMRAAM's Cost

Because of its concern about the escalating cost of the AMRAAM program, the Congress established—in the National Defense Authorization Act for fiscal year 1987—a cost cap of \$7 billion (in 1984 dollars) for the procurement of 24,000 missiles. The act stipulated that the cap could be adjusted for cost increases that result from congressional funding actions. Notice of such adjustments must be provided to the Congress. The Air Force later notified the Congress that it had adjusted the cap to \$7.585 billion (in 1984 dollars) based on congressional reductions in AMRAAM procurement quantities and funding requests for fiscal years 1987 and 1988. According to the Air Force, the congressional reductions caused a less efficient production program.

In September 1988 the Director, Operational Test and Evaluation, notified the Secretary of Defense and the Senate and House Committees on Armed Services and on Appropriations that AMRAAM was not ready for full-rate production and that the procurement quantity for fiscal year 1989 should not exceed 900 missiles. The President's Budget had requested 1,270 missiles. The conference report for the Department of Defense Appropriation Act for fiscal year 1989 directed that no fiscal year 1989 production funds be obligated until the AMRAAM acquisition plan was revised and the Under Secretary of Defense for Acquisition certified that the Director, Operational Test and Evaluation, agreed to the plan. The Department of Defense submitted the revised plan and

certification on December 9, 1988. The revised plan recognized a 4 percent estimated cost increase above the \$7.585 billion adjusted cost cap.⁸

In February 1990 the Secretary of the Air Force notified the Congress that AMRAAM's program acquisition unit cost had increased more than 25 percent. The December 1989 Selected Acquisition Report showed that AMRAAM's estimated procurement cost had risen from \$7.6 to \$9.4 billion (in 1984 dollars).

Causes for Procurement Cost Increases

According to the December 31, 1989, Selected Acquisition Report for the AMRAAM program, the cost increase was caused primarily by changes in assumptions about savings from contractor competition and production learning rates.

Reduced Savings From Competition

The estimate supporting the statutory cost cap assumed that savings from competition would begin in the third production year. The first 2 years were to be negotiated procurements based on the contractors' proposed prices for various portions of the total procurement quantity for each year.

Each contractor's proposal for the third production year, however, was much higher than expected. As a result, the Air Force notified each contractor that the third production year would be a negotiated procurement and requested each contractor to submit certified cost and pricing data. In addition, the Air Force concluded that a postponement of price competition was needed to achieve increased contractor cooperation to resolve a number of design and production problems. As a result, the Air Force delayed the first year of price competition until the fifth production year.

Slower Production Learning Rates

A production cost estimating technique is to project material and labor savings that are expected to result from producing increasingly higher quantities over several years. As with other program cost estimates, the AMRAAM cost estimate of \$7 billion (in 1984 dollars) was based on efficiency improvements realized during the fabrication of development or

⁸In the December 31, 1988, Selected Acquisition Report for the AMRAAM program, the Air Force estimated that the procurement cost would be about 2 percent over the adjusted statutory cost cap, provided that the program was given the authority for multiyear procurement in the later years of the program.

prototype missiles and experience gained from other similar programs. In addition to development data, the latest AMRAAM cost estimate considers the results of negotiated contracts for the first three production years and the contractors' proposals for the fourth production year. On the basis of these data, the projected learning curves for material and labor were adjusted to be less optimistic than those used in earlier estimates.

Substantial Procurement Funds Needed in Future Years

The current cost estimate, which would exceed the adjusted statutory cost cap, is based on the assumption that the administration and the Congress will provide substantially increased funding for AMRAAM production in future years. Between \$0.9 billion and \$1.7 billion per year will be needed in each of the next 8 years to maintain the projected production schedule. If the funds are not provided, the schedule will slip and costs will increase due to, among other things, higher overhead charges per unit and less-than-optimal component procurement quantities. Table 4.1 shows projected missile quantities and funding requirements through fiscal year 1998.

Table 4.1: AMRAAM Procurement Quantity and Funding Requirements for Fiscal Years 1991 Through 1998

Then-year dollars in billions

Fiscal year	Procurement	
	Quantity	Funding
1991	1,800	\$1.3
1992	3,000	1.7
1993	3,000	1.4
1994	3,000	1.2
1995	3,000	1.3
1996	3,000	1.3
1997	3,000	1.2
1998	2,140	0.9

Current Estimate Under Review

When the Under Secretary of Defense for Acquisition endorsed the \$9.4 billion estimated procurement cost, the Under Secretary stated that the Air Force and the Cost Analysis Improvement Group would conduct a full cost review before the May 1990 meeting of the Defense Acquisition Board. Also, the Air Force and the Navy are to review and reconcile their quantity requirements. Among other things, the review of AMRAAM quantity requirements is expected to consider revised threat assumptions and changes in force structure.

In February 1990 the Air Force directed the AMRAAM Program Office to prepare a plan based on the assumption that a total of only 15,500 missiles would be procured. At the completion of our review, no final decision had been made to adjust AMRAAM procurement quantities. Reduced quantities would lower total procurement cost but increase the unit cost of each missile. The Air Force and the contractors also were studying other ways to reduce AMRAAM procurement costs such as accelerating producibility enhancement projects.

Conclusions and Recommendation

In May 1990 the Defense Acquisition Board plans to review the AMRAAM program and make a recommendation to the Secretary of Defense on whether the program should proceed into full-rate production, return to full-scale development, or be terminated. The Under Secretary of Defense for Acquisition has stated that continued low-rate production is not an option.

Conclusions

As of March 1990, the AMRAAM program was not ready for full-rate production. In addition, the Air Force should not award any additional production contracts until significant questions are resolved about the missile's performance, reliability, producibility, and affordability. For example:

- Tests had not yet shown that the missile can accomplish a few remaining critical performance requirements, and the missile's reliability was unacceptable.
- The Department of Defense had authorized over \$2.4 billion for the production of 1,480 missiles, but the contractors were at least 6 months behind in missile deliveries and some of the problems that delayed production had not been resolved. Of the 380 missiles required under contract to be delivered through January 1990, only 134 had been delivered, and the Air Force had stopped accepting missiles because of the poor reliability.
- The total procurement cost had increased substantially—24 percent above the adjusted statutory cost cap—and cost will increase further unless the administration and Congress are willing to provide between \$0.9 billion and \$1.7 billion per year over the next 8 years for AMRAAM procurement. The Air Force and Navy were considering possible reductions in total procurement quantities.

In our opinion, approving additional funds for continued low-rate or full-rate production of AMRAAM before questions about its performance, reliability, producibility, and affordability are resolved will increase the risk that additional missiles will need costly retrofits, weapons in inventory will not perform satisfactorily, and different missile configurations will have to be maintained.

Recommendation

We recommend that the Secretary of Defense not approve any additional AMRAAM production until (1) tests demonstrate that AMRAAM can meet all of its critical performance requirements and that its reliability meets the established requirements, (2) both contractors demonstrate

that they can consistently produce quality missiles at the rates required by their contracts, (3) the Air Force and Navy complete their review of missile quantity requirements, and (4) the Department of Defense determines that the AMRAAM program is affordable within realistic future budget projections and consults with the Congress to ensure that the program complies with the adjusted statutory cost cap.

Matter for Congressional Consideration

The Congress should deny the \$1.34 billion requested for AMRAAM procurement in fiscal year 1991 because the missile's performance, reliability, producibility, and affordability remain questionable. Moreover, missile deliveries from the first production year are at least 6 months behind schedule and additional delays appear likely. In addition, funds have already been appropriated for three additional production years, two of which are fully under contract and one which has the procurement of long-lead items under contract. We believe it is highly unlikely that additional procurement funds will be necessary before fiscal year 1992.

During our review, the Air Force could not provide us with any information regarding the adverse impact, if any, of the Congress not providing fiscal year 1991 procurement funds. Air Force efforts to establish realistic missile delivery schedules and modify the contracts for the second and third production years had not been completed, and the contracts for the fourth production year have not yet been negotiated. Should the contractors resolve their manufacturing problems and begin to produce quality missiles consistently, ample opportunity would be available to rephase delivery schedules to preclude any gaps in production. Denying additional AMRAAM procurement funding for the fifth production year—fiscal year 1991—would reduce financial risks while the Under Secretary of Defense for Acquisition determines if reliability problems can be resolved and if the contractors can recover delivery schedules.

Major Contributors to This Report

**National Security and
International Affairs
Division, Washington,
D.C.**

Norman J. Rabkin, Associate Director
Robert L. Pelletier, Assistant Director
William R. Graveline, Assignment Manager

**Atlanta Regional
Office**

Lee A. Edwards, Regional Management Representative
John L. Grant, Evaluator-in-Charge
Donald C. Dunham, Evaluator
Robert E. Kigerl, Evaluator

Related GAO Products

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